attractive personality which endeared him to all who were intimately associated with him. His kindly interest in his students and assistants and his many generous and helpful deeds in their behalf will long be remembered by those who had the good fortune to work with him.

THOMAS B. OSBORNE

THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE[1]

ADDRESS OF THE PRESIDENT TO THE PHYSIOLOGICAL SECTION

THE PHYSIOLOGICAL BASIS OF SUCCESS

DURING past years it has been customary for the presidents of sections in their addresses either to give a summary of recent investigations, in order to show the position and outlook of the branch of science appertaining to the section, or to utilize the opportunity for a connected account of researches in which they themselves have been engaged, and can therefore speak with the authority of personal experience as well as with that imparted by the presidential chair. The growing wealth of publications with the special function of giving summaries and surveys of the different branches of science, drawn up by men ranking as authorities in the subject of which they treat, renders such an interpretation of the presidential duties increasingly unnecessary, and the various journals which are open to every investigator make it difficult for me to give in an address anything which has not already seen the light in other forms. The association itself, however, has undergone a corresponding modification. Founded as a medium of communication between workers in different parts of the country, it has gradually acquired the not less important significance of a tribunal from which men of science, leaving for a time their laboratories, can speak to an audience of intelligent laymen, including under this term all those who are engaged in the work of the world other than the advancement of science. These men would fain know the lessons that science has to teach in the living of the common life. By standing for a moment on the little pinnacle erected by the physicist, the chemist or the botanist, they can, or should be able to, gain new hints as to the conduct of the affairs of themselves, their town or their state. The enormous advance in the comfort and prosperity of our race during the last century has been due to the application of science, and this meeting of the association may be regarded as an annual mission in which an attempt is made to bring the latest results of scientific investigation into the daily routine of the life of the community.

We physiologists, as men who are laying the foundation on which medical knowledge must be built, have as our special preoccupation the study of man. Although every animal, and indeed every plant, comes within the sphere of our investigations, our main object is to obtain from such comparative study facts and principles which will enable us to elucidate the mechanism of man. In this task we view man, not as the psychologist or the historian does, by projecting into our object of study our own feelings and emotions, but by regarding him as a machine played upon by environmental events and reacting thereto in a way determined by its chemical and physical structure.

Can we not learn something of value in our common life by adopting this objective point of view and regarding man as the latest result of a continuous process of evolution which, begun in far-off ages, has formed, proved and rejected myriads of types before man himself appeared on the surface of the globe?

[1] Winnipeg, 1909.

Adaptation.—In his study of living beings, the physiologist has one guiding principle which plays but little part in the sciences of the chemist and physicist, namely, the principle of adaptation. Adaptation or purposiveness is the leading characteristic of every one of the functions to which we devote in our text-books the chapters dealing with assimilation, respiration, movement, growth, reproduction, and even death itself. Spencer has defined life as "the continuous adjustment of internal relations to external relations." Every phase of activity in a living being is a sequence of some antecedent change in its environment, and is so adapted to this change as to tend to its neutralization and so to the survival of the organism. This is what is meant by adaptation. It will be seen that not only does it involve the teleological conception that every normal activity must be for the good of the organism, but also that it must apply to *all* the relations of living beings. It must therefore be the guiding principle, not only in physiology, with its special preoccupation with the internal relations of the *parts* of the organism, but also in the other branches of biology, which treat of the relations of the living animal to its environment and of the factors which determine its survival in the struggle for existence. Adaptation therefore must be the deciding factor in the origin of species and in the succession of the different forms of life upon this earth.

Origin of Life.—A living organism may be regarded as a highly unstable chemical system which tends to increase itself continuously under the average conditions to which it is subject, but undergoes disintegration as a result of any variation from this average. The essential condition for the survival of the organism is that any such disintegration shall result in so modifying the relation of the system to the environment that it is once more restored to the average in which assimilation can be resumed.

We may imagine that the first step in the evolution of life was taken when, during the chaotic chemical interchanges which accompanied the cooling down of the molten surface of the earth, some compound was formed, probably with absorption of heat, endowed with the property of polymerization and of growth at the expense of surrounding material. Such a substance could continue to grow only at the expense of energy derived from the surrounding medium, and would undergo destruction with any stormy change in its environment. Out of the many such compounds which might have come into being, only such would survive in which the process of exothermic disintegration tended towards a condition of greater stability, so that the process might come to an end spontaneously and the organism or compound be enabled to await the more favorable conditions necessary for the continuance of its growth. With the continued cooling of the earth, the new production of endothermic compounds would probably become rarer and rarer. The beginning of life, as we know it, was possibly the formation of some complex, analogous to the present chlorophyll corpuscles, with the power of absorbing the newly penetrating sun's rays and of utilizing these rays for the endothermic formation of further unstable compounds. Once given an unstable system such as we have imagined, with two phases, viz., (1) a condition of assimilation or growth by the endothermic formation of new material; (2) a condition of "exhaustion," in which the exothermic destructive changes excited by unfavorable external conditions came to an end spontaneously—the great principle of

natural selection or survival of the fittest would suffice to account for the evolution of the ever-increasing complexity of living beings which has occurred in the later history of this globe. The adaptations, *i. e.*, the reactions of the primitive organism to changes in its environment, must become continually more complex, for only by means of increasing variety of reaction can the stability of the system be secured within greater and greater range of external conditions. The difference between higher and lower forms is therefore merely one of complexity of reaction.

The naked protoplasm of the plasmodium of *Myxomycetes,* if placed upon a piece of wet blotting-paper, will crawl towards an infusion of dead leaves, or away from a solution of quinine. It is the same process of adaptation, the deciding factor in the struggle for existence, which impels the greatest thinkers of our times to spend long years of toil in the invention of the means for the offense and defense of their community or for the protection of mankind against disease and death. The same law which determines the downward growth of the root in plants is responsible for the existence to-day of all the sciences of which mankind is proud.

The difference between higher and lower forms is thus not so much qualitative as quantitative. In every case, whatever part of the living world we take as an example, we find the same apparent perfection of adaptation. Whereas, however, in the lower forms the adaptation is within strictly defined limits, with rise in type the range of adaptation steadily increases. Especially is this marked if we take those groups which stand, so to speak, at the head of their class. It is therefore important to try and find out by a study of various forms the physiological mechanism or mechanisms which determine the increased range of adaptation. By thus studying the physiological factors, which may have made for success in the struggle for dominance among the various representatives of the living world, we may obtain an insight into the factors which will make for success in the further evolution that our race is destined to undergo.

It is possible that, even at this time, objections may be raised to the application to man of conclusions derived from a study of animals lower in the scale. It has indeed been urged, on various grounds, that man is to be regarded as exempt from the natural laws which apply to all the other living beings. When we inquire into the grounds for assuming this anomic, this outlawed condition of man, we generally meet with the argument that man creates his own environment and can not therefore be considered to be in any way a product of it. This modification or creation of environment is, however, but one of the means of adaptation employed by man in common with the whole living kingdom. From the first appearance of life on the globe we find that one of the methods adopted by organisms for their self-preservation is the production of some artificial surroundings which protect them from the buffeting of environmental change. What is the mucilaginous envelope produced by microorganisms in presence of an irritant, or the cuticle or shell secreted by the outermost cells of an animal, but the creation of such an environment? All unicellular organisms, as well as the units composing the lowest metazoa, are exposed to and have to resist every change in concentration and composition of the surrounding water. When, however, a body cavity or *cœlom,* filled probably at first with seawater, made its appearance, all the inner cells of the organism were withdrawn from the disturbing influence of variations in

the surrounding medium. The cœlomic fluid is renewed and maintained uniform in composition by the action of the organism itself, so that we may speak of it as an environment created by the organism. The formation of a body cavity filled with salt solution at once increased the range of adaptation of the animals endowed therewith. Thus it enabled them to leave the sea, because they carried with them the watery environment which was essential for the normal activity of their constituent cell units. The assumption of a terrestrial existence on most parts of the earth's surface involved, however, the exposure to greater ranges of temperature than was the case in the sea, and indicated the necessity for still further increase in the range of adaptation. Every vital process has its optimum temperature at which it is carried out rapidly and effectively. At or a little above freezing point the chemical processes concerned in life are suspended, so that over a wide range of the animal kingdom there must be an almost complete suspension of vital processes during the winter months, and at all times of the year a great dependence of the activity of these processes on the surrounding temperature. It is evident that a great advantage in the struggle for existence was gained by the first animals which succeeded in securing thermal as well as chemical constancy of environment for their cells, thus rendering them independent of changes in the external medium. It is interesting to note that the maintenance of the temperature of warm-blooded animals at a constant height is a function of the higher parts of the central nervous system. An animal with spinal cord alone reacts to changes of external temperature exactly like a cold-blooded animal, the activity of its chemical changes rising and falling with the temperature. In the intact mammal, by accurately balancing heat loss from the surface against heat production in the muscles, the central nervous system ensures that the body fluid which is supplied to all the active cells has a temperature which is independent of that of the surrounding medium. These are fundamental examples of adaptation effected by creation of an environment peculiar to the animal. Numberless others could be cited which differ only in degree from the activity of man himself. In some parts of this country, for instance, the activity of the beaver in creating an artificial environment has until lately been more marked than that of man himself. We are not justified, then, in regarding mankind as immune to the operation of natural forces which have determined the sequence of life on the surface of the globe. The same laws which have determined his evolution and his present position as the dominant type on the earth's surface will determine also his future destiny.

We are not, however, dealing with or interested in simple survival. Lower forms of life are probably as abundant on the surface of the globe as they were at any time in its history. Survival, as Darwin pointed out, is a question of differentiation. When in savage warfare a whole tribe is taken captive by the victorious enemy, the leaders and fighting men will be destroyed, while the slaves will continue to exist as the property of the victors. Survival, then, may be determined either by rise or by degradation of type. Success involves the idea of dominance, which can be secured only by that type which is the better endowed with the mechanisms of adaptation required in the struggle against other organisms.

Among the many forms of living matter which may have come into being in the earlier stages of the history of the earth,

one form apparently became predominant and must be regarded as the ancestor of all forms of life, whether animal or vegetable, viz., the nucleated cell. The almost complete identity of the phenomena involved in cell division throughout the living kingdom indicates that all unicellular organisms and all organisms composed of cells have descended from a common ancestor, and that the mode of its reproduction has been impressed upon all its descendants throughout the millions of years which have elapsed since the type was first evolved. The universal distribution of living cells renders it practically impossible for us to test the possibility of a spontaneous abiogenesis or new formation of living from non-living matter at the present time. We can not imagine that all the various phenomena which we associate with life were attributes of the primitive life stuff. Even if we had such stuff at our disposal, it would be difficult to decide whether we should ascribe the possession of life to it, and there is no doubt that any such half-way material would, directly it was formed, be utilized as pabulum by the higher types of organism already abounding on the surface of the globe.

Integration and Differentiation.—An important step in the evolution of higher forms was taken when, by the aggregation of unicellular organisms, the lowest metazoon was formed. In its most primitive forms the metazoon consists simply of a cell colony, but one in which all individuals are not of equal significance. Those to the outer side of the mass, being exposed to different environmental advantages from those within, must even during the lifetime of the individual have acquired different characteristics. Moreover, the sole aim of such aggregation being to admit of cooperation by differentiation of function between the various cell units, the latter become modified according to their position, some cells becoming chiefly alimentary, others motor, and others reproductive. Cooperation and differentiation are, however, of no use without coordination. Each part of the organism must be in a position to be affected by changes going on in distant parts, otherwise cooperation could not be effected. This cooperation in the lowest metazoon seems to be carried out by utilization of the sensibility to chemical stimuli already possessed by the unicellular organism. We have thus coordination by means of chemical substances ("hormones") produced in certain cells and carried thence by the tissue fluids to other cells of the body, a mechanism of communication which we find even in the highest animals, including man himself. To such chemical stimuli we may probably ascribe the accumulation of wandering mesoderm cells—*i. e.*, phagocytes—in an organism such as a sponge, around a seat of injury or any foreign substance that has been introduced. By this mechanism it is possible for distant parts of the body to react to stimulation of any one part of the surface. Communication by this means is, however, slow, and may be compared to the state of affairs in civilized countries before the invention of the telegraph, when messengers had to ride to different parts of the kingdom in order to arouse the whole nation for defense or attack.

Foresight and Control.—Increased speed of reaction and therefore increased powers in the struggle for existence were obtained when a nervous system was formed, by a modification of the cells forming the outer surface of the organism. By the growth of long processes from these cells a conducting network was provided, running through all parts of the body and affording a channel for the rapid propagation of

excitation from the surface to the deeper parts, as well as from one part of the surface to another. From this same layer were produced the cells which, as muscle fibers, would act as the motive mechanism of the organism. Thus, from the beginning, the chief means of attack or escape were laid down in close connection with the surface from which the stimuli were received. A further step in the evolution of the nervous system consisted in the withdrawal of certain of the sensory or receptor cells from the surface, so that a specially irritable organ, the central nervous system, was evolved, which could serve as a distributing center for the messages or calls to action initiated by changes occurring at the surface of the body. At its first appearance this central nervous system would hardly deserve the epithet of "central," since it formed a layer lying some distance below the surface, and extending over a considerable area; though we find that very soon there is an aggregation of the special cells to form ganglia, each of which might be regarded as presiding over the reactions of that part of the animal in which it is situated. Thus in the segmental worm-like animals a pair of ganglia is present in each body segment, and the chain of ganglia are united by longitudinal strands of nerve fibers to form the ganglionated cord, or central nervous system.

Such a diffused nervous system, in which all ganglia were of equal value, could, however, only act for the common weal of the whole body when a reaction initiated by stimulation at one part was not counteracted by an opposing reaction excited from another part of the surface. For survival it is necessary that in the presence of danger, *i. e.*, an environment threatening the life of the individual or race, the whole activities of the organism should be concentrated on the one common purpose, whether of escape or defense. This could be effected only by making one part of the central nervous system predominant over all other parts, and the part which was chosen for this predominance was the part situated in the neighborhood of the mouth. This, in animals which move about, is the part which always precedes the rest of the body, and therefore the part which first experiences the sense impressions, favorable or dangerous, arising from the environment. It is this end that has to appreciate the presence or approach of food material, as well as the nature of the medium into which the animal is being driven by the movements of its body. Thus a predominance of the front end of the nervous system was determined by the special development at this end of those sense organs or sensory cells which are *projicient* —*i. e.*, are stimulated by changes in the environment proceeding from disturbances at a distance from the animal. The sensory organs of vision and the organs which correspond to our olfactory sense organs and are aroused by minute changes in chemical composition of the surrounding medium, are always found especially at the front or mouth end of the organism. The chances of an animal in the struggle for existence are determined by the degree to which the responses of the animal to the *immediate* environment are held in check in consequence of stimuli arising from *approaching* events. The animal, without power to see or smell or hear its enemy, will receive no impulse to fly until it is already within its enemy's jaws. It must therefore be an advantage to any animal that the whole of its nervous system should be subservient to those ganglia or central collections of nerve cells which are in direct connection with the projicient sense organs in the head. This subservi-

ence is secured by endowing the head center with a power, firstly, of controlling and abolishing the activities (*i. e.*, all those aroused by external stimuli) of all other parts of the central nervous system, and, secondly, of arousing these parts to a reaction immediately determined by the impression received from the projicient sense organs of the head and originated by some change in the surroundings of the animal which has not yet affected the actual surface of its body.

Education by Experience.—The factors which so far determine success in the struggle for predominance are, in the first place, foresight and power to react to coming events, and, in the second place, control of the whole activities of the organism by that part of the central nervous system which presides over the reaction. The animal therefore profits most which can subordinate the impulses of the present to the exigencies of the future.

An organism thus endowed is still, however, in the range of its reactions, a long way behind the type which has attained dominance to-day. The machinery we have described, when present in its simplest form, suffices for the carrying out of reactions or adaptations which are determined immediately by sense impressions, advantage being given to those reactions which are initiated by afferent stimuli affecting the projicient sense organs at the head end of the animal. With the formation of the vertebrate type, and probably even before, a new faculty makes its appearance. Up to this point the reactions of an animal have been what is termed "fatal," not in the sense of bringing death to the animal, but as inexorably fixed by the structure of the nervous system inherited by the animal from its precursors. Thus it is of advantage to a moth that it should be attracted by, and fly towards light objects—*e. g.*, white flowers—and such a reactivity is a function of the structure of its nervous system. When the light object happens to be a candle flame the same response takes place. The first time that the moth flies into and through the candle flame, it may only be scorched. It does not, however, learn wisdom, but the reaction is repeated so long as the moth can receive the light stimuli, so that the response, which in the average of cases is for the good of the race, destroys the individual under an environment which is different from that under which it was evolved. There is in this case no possibility of educating the individual. The race has to be educated to new conditions by the ruthless destruction of millions of individuals, until only those survive and impress their stamp on future generations whose machinery, by the accumulation and selection of minute variations, has undergone sufficient modifications to determine their automatic and "fatal" *avoidance* of the harmful stimulus.

The next great step in the evolution of our race was the modification of the nervous system which should render possible the education of the individual. The mechanism for this educability was supplied by the addition, to the controlling sensory ganglia of the head, of a mass of nervous matter which could act, so to speak, as an accessory circuit to the various reflex paths already existing in the original collection of nerve ganglia. This accessory circuit, or upper brain, comes to act as an organ of memory. Without it a child might, like the moth, be attracted by a candle flame and approach it with its hand. The injury ensuing on contact with the flame would inhibit the first movement and cause a drawing back of the hand. In the simple reflex mechanism there is no reason why the same series of events should not be repeated indefinitely, as in the case of the moth. The central nervous system, how-

ever, is so constituted that every passage of an impulse along any given channel makes it easier for subsequent impulses to follow the same path. In the new nerve center, which presents a derived circuit for all impulses traversing the lower centers, the response to the attractive impulse of the flame is succeeded immediately by the strong inhibitory impulses set up by the pain of the burn. Painful impressions are always predominant. Since they are harmful, the continued existence of the animal depends on the reaction caused by such impressions taking the precedence of and inhibiting all others. The effect therefore of such a painful experience on the new upper brain must far outweigh that of the previous impulse of attraction. The next time that a similar attractive impression is experienced the derived impulse traversing the upper brain arouses, not the previous primary reaction, but the secondary one, viz., that determined by the painful impressions attending contact with the flame. As a result, the whole of the lower tracts, along which the primary reaction would have traveled, are blocked, and the reaction—now an educated one—consists in withdrawal from or avoidance of the formerly attractive object. The burnt child has learned to dread the fire.

The upper brain represents a nerve mechanism without distinct paths, or rather with numberless paths presenting at first equal resistance in the various directions. As a result of experience, definite tracts are laid down in this system, so that the individual has the advantage not only of his lower reflex machinery for reaction, but also of a machinery which with advance in life is adapted more and more to the environment in which he happens to be. This educable part of the nervous system—*i. e.*, the one in which the direction of impulses depends on past experience and on habit—is represented in vertebrates by the cerebral hemispheres. From their first appearance they increase steadily in size as we ascend the animal scale, until in man they exceed by many times in bulk the whole of the rest of the nervous system.

We have thus, laid down automatically, increased power of foresight, founded on the law of uniformity. The candle flame injures the skin once when the finger is brought in contact with it. We assume that the same result will follow each time that this operation is repeated. This uniformity is also assumed in the growth of the central nervous system and furnishes the basis on which the nerve paths in the brain are laid down. The one act of injury which has followed the first trial of contact suffices in most cases to inhibit and to prevent any subsequent repetition of the act.

The Faculty of Speech.—If we consider for a moment the vastness and complexity of the stream of impressions which must be constantly pouring into the central nervous system from all the sense organs of the body, and the fact that, at any rate in the growing animal, every one of these impulses is, so to speak, stored in the upper brain, and affects the whole future behavior of the animal, even the millions of nerve cells and fibers which are to be found in the human nervous system would seem to be insufficient to carry out the task thrown upon them. Further development of the adaptive powers of the animal would probably have been rendered impossible by the very exigencies of space and nutrition, had it not been for the development of the power of speech. A word is a fairly simple motor act and produces a correspondingly simple sensory impression. Every word, however, is a shorthand expression of a vast sum of experience, and

by using words as counters it becomes possible to increase enormously the power of the nervous system to deal with its own experience. Education now involves the learning of these counters and of their significance in sense experience; and the reactions of the highest animal, man, are for the most part carried out in response to words and are governed by past education of the experience-content involved in each word.

The power of speech was probably developed in the first place as a means of communication among primitive man living in groups or societies; as a means, that is to say, of procuring cooperation of different individuals in a task in which the survival of the whole race was involved. But it has attained still further significance. Without speech the individual can profit by his own experience and to a certain limited extent by the control exercised by the older and more experienced members of his tribe. As soon as experience can be symbolized in words, it can be dissociated from the individual and becomes a part of the common heritage of the race, so that the whole past experience of the race can be utilized in the education—*i. e.*, the laying down of nerve tracts—in the individual himself. On the other hand, the community receives the advantage of the foresight possessed by any individual who happens to be endowed with a central nervous system which transcends that of his fellows in its powers of dealing with sense impressions or other symbols. The foresight thus acquired by the whole community must be of advantage to it and serve for its preservation. It is therefore natural that in the processes of development and division of labor, which occur among the members of a community just as among the cell units composing an animal, a class of individuals should have been developed, who are separated from the ordinary avocations, and are, or should be, maintained by the community, in order that they may apply their whole energies to the study of sequences of sense impressions. These are set into words which, as summary statements of sequence, are known to us as the laws of nature. These natural laws become the property of the whole community, become embodied by education into the nervous system of its individuals, and serve therefore as the experience which will determine the future behavior of its constituent units. This study of the sequence of phenomena is the office of science. Through science the whole race thus becomes endowed with a foresight which may extend far beyond contemporary events and may include in its horizon not only the individual life, but that of the race itself as of races to come.

Social Conduct.—I have spoken as if every act of the animal were determined by the complex interaction of nervous processes whose paths through the higher parts of the brain had been laid down by previous experience, whether of phenomena or of words as symbolical of phenomena. The average conduct, however, of the individual, determined at first in this way, became by repetition automatic—*i. e.*, the nerve paths are so facilitated by frequent use that a given impulse can take only the direction which is set by custom. The general adoption of the same line of conduct by all the individuals of a community in face of a given condition of the environment gave in most cases an advantage to those individuals who were endowed with a nervous system of such a character that the path could be laid down quickly and with very little repetition. Thus we get a tendency, partly by selection, largely by education, to the establishment of reactions which, like the instincts of animals,

are almost automatic in character. As MacDougall has pointed out, the representations in consciousness of automatic tendencies are the emotions. Moral conduct, being that behavior which is adapted to the individual's position in his community, is largely determined by these paths of automatic action, and the moral individual is he whose automatic actions and consequent emotions are most in accord with the welfare of his community, or at any rate with what has been accepted as the rule of conduct for the community.

Rise in Type dependent on Brain.—Thus, in the evolution of the higher from the lower type, the physiological mechanisms, which have proved the decisive factors, can be summed up under the headings of integration, foresight and control. In the process of integration we have not only a combination of units previously discrete, but also differentiation of structure and function among the units. They have lost, to a large extent, their previous independence of action and, indeed, power of independent action, the whole of their energies being now applied to fulfilling their part in the common work of the organism. At first bound together by but slight ties and capable in many cases of separating to form new cell colonies, they have finally arrived at a condition in which each one is absolutely dependent for its existence on its connection with the rest of the organism and is also essential to the well-being of every other part of the organism.

This solidarity, this subjection of all selfish activity to a common end, namely, preservation of the organism, could only be effected by a gradual increase in the control of all parts by one master tissue of the body, whose actions were determined by impulses arriving from sense organs which themselves were set into activity by coming events. We thus have with the rise in type a gradually rising scale in powers of foresight, in control by the central nervous system, and in the solidarity of the units of which the organism is composed.

In the struggle for existence the rise in type has depended, therefore, on the central nervous system and its servants. Rise in type implies increased range of adaptation, and we have seen that this increased range, from the very beginning of a nervous system, was bound up with the powers of this system. Whatever opinion we may finally arrive at with regard to the types of animals which we may claim as our ancestors on the line of descent, there can be no doubt that Gaskell is right in the fundamental idea which has guided his investigations into the origin of vertebrates. As he says, "the law for the whole animal kingdom is the same as for the individual. Success in this world depends upon brains." The work by this observer which has lately appeared sets forth in greater detail than I have been able to give you today the grounds on which this assertion is based, and furnishes one of the most noteworthy contributions to the principles of evolution which have been published during recent years.

We must not, however, give too restrictive or common a meaning to the expression "brains" used by Gaskell in the dictum quoted above. By this word we imply the whole reactive system of the animal. In the case of man, as of some other animals, his behavior depends not merely on his intellectual qualities or powers, to which the term "brain" is often in popular language confined, but on his position as a member of a group or society. His automatic activities in response to his ordinary environment, all those social acts which we ascribe in our-

selves to our emotions or conscience, are determined by the existence of tracts in the higher parts of his brain, access to which has been opened by the ruthless method of natural selection and which have been deepened and broadened under the influence of the pleasurable and painful impressions which are included in the process of education. All the higher development of man is bound up with his existence as a member of a community, and in trying to find out the factors which will determine the survival of any type of man, we must give our attention, not to the man, but to the tribe or community of which he is a member, and must try to find out what kind of behavior of the tribe will lead to its predominance in the struggle for existence.

Political Evolution.—The comparison of the body politic with the human body is as old as political economy itself, and there is indeed no reason for assuming that the principles which determine the success of the animals formed by the aggregation of unicellular organisms should not apply to the greater aggregations or communities of the multicellular organisms themselves. It must be remembered, however, that the principles to which I have drawn your attention are not those that determine survival, but those which determine rise of type, what I have called success. Evolution may be regressive as well as progressive. Degeneration, as Lankester has shown, may play as great a part as evolution of higher forms in determining survival. The world still contains myriads of unicellular organisms as well as animals and plants of all degrees and complexity and of rank in the scale of life. All these forms are subordinate to man, and when in contact with him are made to serve his purposes. In the same way all mankind will not rise in type. Many races will die out, especially those who just fall short of the highest type, while others by degradation or differentiation may continue to exist as parasites or servants of the higher type.

Mere association into a community is not sufficient to ensure success; there must also be differentiation of function among the parts, and an entire subordination of the activity of each part to the welfare of the whole. It is this lesson which we English-speaking races have at the present time most need to learn. In the behavior of man almost every act is represented in consciousness as some emotion, experience or desire. The state of subordination of the activities of all units to the common weal of the community has its counterpart in consciousness as the "spirit of service." The enormous value of such a condition of solidarity among the individuals constituting a nation, inspired, as we should say, by this spirit of service, has been shown to us lately by Japan. In our own case the subordination of individual to state interests, such as is necessary for the aggregation of smaller primitive into larger and more complex communities, has always presented considerable difficulty and been accomplished only after severe struggle. Thus the work begun by Alexander Hamilton and Washington, the creation of the United States, is still, even after the unifying process of a civil war, incomplete and marred by contending state and individual interests. The same sort of difficulties are being experienced in the integration of the units, nominally under British control, into one great nation, in which all parts shall work for the good of the whole and for mutual protection in the struggle for survival.

The Lesson of Evolution.—Just as pain is the great educator of the individual and is responsible for the laying down of the

nervous paths, which will determine his whole future conduct and the control of his lower by his higher centers, so hardship has acted as the integrator of nations. It is possible that some such factor with its attendant risks of extermination may still be necessary before we attain the unification of the British empire, which would seem to be a necessary condition for its future success. But if only our countrymen can read the lesson of evolution and are endowed with sufficient foresight, there is no reason why they should not, by associating themselves into a great community, avoid the lesson of the rod. Such a community, if imbued by a spirit of service and guided by exact knowledge, might be successful above all others. In this community not only must there be subordination of individual to communal interests, but the behavior of the community as a whole must be determined by anticipation of events—*i. e.*, by the systematized knowledge which we call science. The universities of a nation must be like the eyes of an animal, and the messages that these universities have to deliver must serve for the guidance and direction of the whole community.

This does not imply that the scientific men, who compose the universities and are the sense organs of the community, should be also the rulers. The reactions of a man or of a higher mammal are not determined immediately by impulses coming from his eyes or ears, but are guided by these in association with, and after they have been weighed against, a rich web of past experience, the organ of which is the higher brain. It is this organ which, as the statesman of the cell community, exercises absolute control. And it is well that those who predicate an absolute equality or identity among all the units of a community should remember that, although all parts of the body are active and have their part to play in the common work, there is a hierarchy in the tissues—different grades in their value and in their conditions. Thus every nutritional mechanism of the body is subordinate to the needs of the guiding cells of the brain. If an animal be starved, its tissues waste; first its fat goes, then its muscles, then its skeletal structures, finally even the heart. The brain is supplied with oxygen and nourishment up to the last. When this, too, fails, the animal dies. The leading cells have first call on the resources of the body. Their needs, however, are soon satisfied, and the actual amount of food or oxygen used by them is insignificant as compared with the greedy demands of a working muscle or gland cell. In like manner every community, if it is to succeed, must be governed, and all its resources controlled, by men with foreseeing power and rich experience—*i. e.*, with the wisdom that will enable them to profit by the teachings of science, so that every part of the organism may be put into such a condition as to do its optimum of work for the community as a whole.

At the present time it seems to me that, although it is the fashion to acquiesce in evolution because it is accepted by biologists, we do not sufficiently realize the importance of this principle in our daily life, or its value as a guide to conduct and policy. It is probable that this doctrine had more influence on the behavior of thinking men in the period of storm and controversy which followed its promulgation fifty years ago, than it has at the present day of lukewarm emotions and second-hand opinions. Yet, according to their agreement with biological laws, the political theories of to-day must stand or fall. It is true that in most of them the doctrine of evolution is invoked as supporting

one or other of their chief tenets. The socialist has grasped the all-importance of the spirit of service, of the subordination of the individual to the community. The aristocrat, in theory at any rate, would emphasize the necessity of placing the ruling power in the hands of the individuals most highly endowed with intelligence and with experience in the affairs of nations. He also appreciates the necessity of complete control of all parts by the central government, though in many cases the sense organs which he uses for guidance are the traditions of past experience rather than the science of to-day. The liberal or individualist asserts the necessity of giving to each individual equal opportunities, so that there may be a free fight between all individuals in which only the most highly gifted will survive. It might be possible for another Darwin to give us a politic which would combine what is true in each of these rival theories, and would be in strict accord with our knowledge of the history of the race and of mankind. As a matter of fact the affairs of our states are not determined according to any of these theories, but by politicians, whose measures for the conduct of the community depend in the last resort on the suffrages of their electors—*i. e.*, on the favor of the people as a whole. It has been rightly said that every nation has the government which it deserves. Hence it is all-important that the people themselves should realize the meaning of the message which Darwin delivered fifty years ago. On the choice of the people, not of its politicians, on its power to foresee and to realize the laws which determine success in the struggle for existence, depends the future of our race. It is the people that must elect men as rulers in virtue of their wisdom rather than of their promises. It is the people that must insist on the provision of the organs of foresight, the workshops of exact knowledge. It is the individual who must be prepared to give up his own freedom and ease for the welfare of the community.

Whether our type is the one that will give birth to the super-man it is impossible to foresee. There are, however, two alternatives before us. As incoherent units we may acquiesce in an existence subordinate to or parasitic on any type which may happen to achieve success, or as members of a great organized community we may make a bid for determining the future of the world and for securing the dominance of our race, our thoughts and ideals.

E. H. STARLING

VACCINE THERAPY AND IMMUNIZATION

Two of the great hospitals of London, as we learn from the London *Times*, St. Mary's, at Paddington, and the Mount Vernon Hospital for Consumption, at Hampstead and Northwood, have recently issued appeals on behalf of their special funds for the study and practise of vaccine therapy and for the further development of immunization.

At the Mount Vernon Hospital the direction of the department has been committed to Dr. R. W. Allen, who has been directing his attention largely to affording protection against catarrh and influenza, and who will be applying the same principles to the treatment and, it may reasonably be hoped, to the cure of the forms of tuberculosis of the lung which are still confined to a somewhat limited area. In these, as in tuberculosis of the joints, there is every reason to expect the ultimate subjugation of the invading bacilli by the natural forces evoked through the agency of inoculations; but, in the one case as in the other, the demand for special resources arises from the fact that the application of the principle involved has not yet been brought within the scope of merely bedside observation, and must still be guided by laboratory work of a kind which occupies much time and